UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Mathematics, Statistics and Informatics

2223-1-E1301Q088

Aims

The course Mathematics and Informatics gives the background to acquire the basic knowledge about the fundamental definitions and results of calculus, together with the main concepts of informatics, with a particular focus on the relationships between computer science and biology (e.g. biological databases and problems in bioinformatics).

1. Knowledge and understanding.

At the end of the course the student will gain knowledge about:
- the basic mathematical definitions and their meaning;
- “computational thinking”, in order to critically use concepts and tools of computer science (algorithms, computational methods, software) for the solution of a given problem;
- the choice of the proper sampling and statistical methods, and the interpretation of outcomes in the analysis of biological data.

2. Ability to apply knowledge and understanding.

At the end of the course, the student will be able to apply the knowledge listed in item 1 to solve the proposed exercises in mathematics, to solve and analyze problems in statistics, and to apply the computational tools for the solution of problems in biological applications.

3. Making judgment.

The student will be able to process the acquired knowledge by identifying the appropriateness of the applications of the mathematical definitions, and choosing the proper statistical and computational methods for different applications.

4. Communication skills.

At the end of the course the student will be able to use an appropriate scientific vocabulary, and to communicate with adequate language in oral/written reports.

5. Learning ability.

At the end of the course, the students will have acquired the necessary competencies to tackle in autonomy the mathematical problems that they will encounter during the course of studies, and will be able to apply the learned skills in those courses that have these as prerequisites. The student will also gain skills in the elaboration, analysis, and application of the acquired knowledge in other courses related to the application of statistical and computational methods for biological data analysis.

Contents

Mathematics

Vector calculus, matrix algebra, eigenvalues and eigenvectors, asymptotic behaviour and study of function of one variable, derivation, functions of two or more variables, differential operators, expansion in power series of elementary functions, integration of elementary functions, integration of elementary ordinary differential equations.

Statistics
Fundamentals of descriptive (population and sample, measures of centre/dispersion/position, graphical representations) and inferential statistics (probability distributions, hypothesis testing) for the analysis of biological data.

Informatics

Introduction to computer science. Algorithms, computational thinking, and basics of structured programming. Notions of computational complexity. DNA computing. Fundamentals of bioinformatics, computational biology, systems biology. Bio-inspired meta-heuristics.

Detailed program

Mathematics

Vector calculus (scalar and vector product, equation of a straight line in vector form), matrix algebra (basic definitions, algebra of matrices, determinant, inverse, transpose, eigenvalues and eigenvectors), asymptotic behaviour and study of function (basic definitions, elementary functions, trigonometric functions, power laws, exponential functions, logarithmic functions, limits , asymptotes, rules of differentiation, stationary points, maxima and minima of function), functions of two or more variables, gradient, divergence, curl, expansion in power series of elementary functions (power series, Taylor's expansion of a function, expansion of exponential, expansion of elementary trigonometric functions), integration of elementary functions (basic definitions, rules of integration, integration by change of variable, integration by parts), integration of elementary ordinary differential equations (integration by separation of variables, general solution, particular solution, application to population dynamics).

Statistics

1) Descriptive statistics. Introduction to statistics (types of data, collecting sample data). Summarizing and graphing data (frequency distributions, histograms, boxplots). Statistics for describing, exploring and comparing data (measures of center, measures of variation, measures of relative standing).

2) Inferential statistics. Basic concepts of probability. Probability distributions (uniform, binomial, normal, t distribution). Sampling distributions and estimators. Hypothesis testing. Correlation and regression.

Informatics

1) Introduction to computer science. Principles of computer operations (von Neumann architecture, fetch-execute cycle). Data representation.
2) Computational thinking and basics of structured programming. Definition of algorithm. From problems to algorithms, from algorithms to programs. Programming languages. Structured programming and pseudo-code. Notions of computational complexity. DNA computing: Adleman's experiment.
3) Fundamentals of bioinformatics, computational biology and systems biology. Biological databases. Sequence alignment: algorithms and heuristics. Protein folding, molecular docking. Computational approaches for complex biological systems.
4) From biology to computer science: bio-inspired computational methods, and their applications in bioinformatics.

Prerequisites

Mathematics

Basic concepts of algebra and geometry, concept of number, elementary and periodic function, calculus on power laws, concept of equation and inequality, fundamental equation of straight line, circle and parabola.

Statistics

None.

Informatics

Basic notions of biology.

Teaching form

Mathematics

The teaching of the course includes both lectures and exercises. Lectures are theoretical lessons in which the knowledge of definitions, results and relevant examples is given. The exercises involve the resolution of exercises and the analysis of mathematical problems, allowing the student to verify his/her ability to apply the theoretical notions acquired during the lectures. For this modules, there will be tutorials aimed at improving the capabilities of students.

Statistics and Informatics

Classroom lectures supported by PowerPoint slides. Tutoring activity for the use of spreadsheets and bioinformatics tools, and the solution of homework assignments.

Textbook and teaching resource

Mathematics

Material presented on the board by the lecturer.
Auxiliary recommended textbook:
- D. Benedetto, M. Degli Esposti, C. Maffei, “Matematica per le scienze della vita”, Casa Editrice Ambrosiana, or any other equivalent textbook for undergraduates in physical sciences.

Statistics

All the educational material – slides and video recordings of lectures/tutoring hours - will be available on Moodle platform.
Textbooks:
- M.M. Triola, M.F. Triola. Fondamenti di statistica per le discipline biomediche, Pearson, 2017
- M.C. Whitlock, D. Schluter. Analisi statistica dei dati biologici, Zanichelli, 2022

Informatics

All the educational material – slides and video recordings of lectures/tutoring hours - will be available on Moodle platform.
Textbooks:
- M.G. Schneider, J.L. Gersting. Informatica. Algoritmi, architetture, linguaggi, applicazioni. Maggioli Editore, Apogeo Education, 2020
- M. Helmer Citterich, F. Ferrè, G. Pavesi, C. Romualdi, G. Pesole. Fondamenti di Bioinformatica. Zanichelli, 2018

Semester

Annuals
Mathematics: first semester
Statistics and Informatics: second semester

Assessment method

Mathematics

Written exam (1 hour and 30 mins) consisting of multiple-choice questions on topics presented during the course and tutorials aimed at evaluating the ability of students to apply the acquired concepts to solve proposed exercises in Mathematics.
First-year students regularly enrolled can take mid-term exams, following the same assessment method used for official examination.

There is no oral examination.

Statistics and Informatics

Written exam (1 hour and 30 mins), consisting in multiple-choice questions and open questions about the topics presented during the lectures and tutoring hours, aimed at evaluating the ability of the student in applying the acquired knowledge to solve the proposed exercises and theoretical aspects of Statistics and Informatics.
First-year students regularly enrolled can take mid-term exams, following the same assessment method used for the official examination.

There is no oral examination.

Office hours

By appointment with the lecturer through e-email.

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Sustainable Development Goals

QUALITY EDUCATION